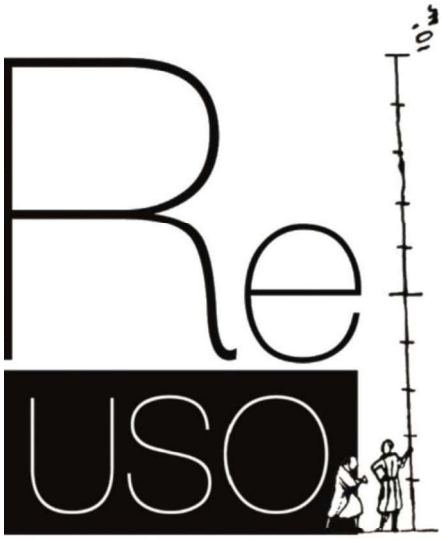
Documentation, Restoration and Reuse of Heritage

2-4 November 2022
Porto, Portugal

BOOK OF PROCEEDINGS

INSTITUTO DA CONSTRUÇÃO
U.PORTO FEUP FACULDADE DE ENGENHARIA UNIVERSIDADE DO PORTO
CONSTRUCT



Documentation, Restoration and Reuse of Heritage

Book of Proceedings

2-4 November 2022
Porto, Portugal

www.fe.up.pt/reuso

Proceedings of the

Xth edition of the ReUSO - Documentation, Restoration and Reuse of Heritage

Format: Ebook (pdf)

ISBN: 978-972-752-296-5

Porto, Portugal, 2-4 November 2022

H. Varum, A. Furtado & J. Melo (eds.)

Chair

Humberto Varum
U.Porto / FEUP, Conference Chair

Honorary Committee

António Sousa Pereira (Rector) | UP | Portugal
Rui Artur Bártolo Calçada (Director) | FEUP | Portugal
João Pedro Xavier (Director) | FAUP | Portugal
Ignazio Marcello Mancini (Dean) | U. Basilicata | Italy
Giuseppe De Luca (Director) | U. Firenze | Italy
Aldo Corcella (Director) | DiCEM/U. Basilicata | Italy
Susanna Caccia Gherardini (Professor) | U. Firenze | Italy

ReUSO Founding Committee

Stefano Bertocci | U. Firenze | Italy
Giovanni Minutoli | U. Firenze | Italy
Fauzia Farneti | U. Firenze | Italy
Susana Mora | U.P. Madrid | Spain
Silvio Van Riel | U. Firenze | Italy

Organising Committee

Humberto Varum, Portugal
Alexandre Costa, Portugal
André Furtado, Portugal
Aníbal Costa, Portugal
António Arêde, Portugal
Bruno Marques, Portugal
Bruno Quelhas, Portugal
Cilísia Ornelas, Portugal
Clara Vale, Portugal
Esmeralda Paupério, Portugal
Hipólito Sousa, Portugal
Hugo Rodrigues, Portugal
João Miranda Guedes, Portugal
José Melo, Portugal
José Miguel Rodrigues, Portugal
Marco Faggella, Italy
Miguel Malheiro, Portugal
Nelson Vila Pouca, Portugal
Patrício Rocha, Portugal
Pedro Delgado, Portugal
Rui Póvoas, Portugal
Rui Silva, Portugal
Teresa Ferreira, Portugal
Vasco Freitas, Portugal
Xavier Romão, Portugal

Scientific Committee

Humberto Varum, Portugal
Agostino Catalano, Italy
Alexandre Costa, Portugal
Alice Tavares, Portugal
Ana Tostões, Portugal
Ana Velosa, Portugal
André Furtado, Portugal
Andrea Nanetti, Singapore
Angelo Lucchini, Italy
Aníbal Costa, Portugal
Antonella Guida, Italy
Antonello Pagliuca, Italy
Antoni Moreno-Navarro, Spain
António Arêde, Portugal
Antonio Conte, Italy
Calogero Bellanca, Italy
Camilla Mileto, Spain
Caterina Palestini, Italy
Clara Vale, Portugal
Damiano Lacobone, Italy
Juan A. García Esparza, Spain
Juan B. Aznar Mollá, Spain
Lorenzo Jurina, Italy
Luis Miguel Correia, Portugal
Luis Palmero Iglesias, Spain
Manlio Montuori, Italy
Manuela Grecchi, Italy
Marcello Balzani, Italy
Marco D'Orazio, Italy
Marco Faggella, Italy
Marco Morandotti, Italy
Marco Pretelli, Italy
Marco Tanganelli, Italy
Marcos Tognon, Brazil
Maria Fernandes, Portugal
María Paz Sáez Pérez, Spain
Mariana Correira, Portugal
Marianna Calia, Italy
Mariella De Fino, Italy
Marina Fumo, Italy

CONTENTS

Plenary Keynote Lectures

Participants communications

Projection mapping for the enhancement of Estense wall paintings: a workflow for complex surfaces and the management of colors

Manuela Incerti - Dipartimento di Architettura, Università di Ferrara, Italy, icm@unife.it

Stefano Giannetti - Dipartimento di Architettura, Università di Ferrara, Italy, stefano.giannetti@unife.it

Abstract: The present paper constitutes the development of research work carried out in 2018 as part of a project to enhance and promote the Estense architecture. Through the projection mapping technique, we wanted to compensate for the partially compromised decorations of the facades of some Estense dwellings, by building a permanent system capable of periodically projecting their re-construction directly onto the existing surfaces. The critical issues analyzed during the process carried out in the past year of-fered the basis for the development of a new methodology, attentive to the result from the outset and more consistent with the objectives of enhancing the architecture itself.

Keywords: projection mapping; architectural survey; historic reconstruction

1. Introduction

In recent years, *projection mapping* events have reached such diffusion as to characterize a real artistic and show genre. Numerous international events gather these shows. To name a few: from the Circle of Light Festival in Moscow, to the iMapp in Bucharest, up to the most recent Video Mapping Festival held in the Hauts de France region.

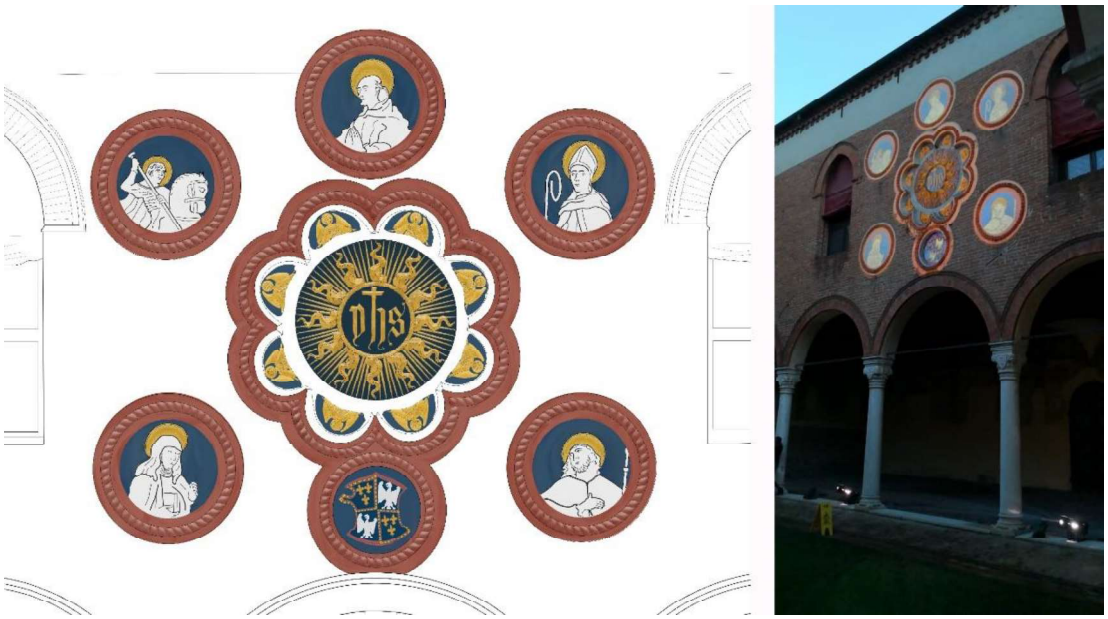


Figure 1. The reconstruction drawing (left) and the projection mapping in Museum Casa Romei (Ferrara, 2018), (right).

Although widely used in the field of cultural heritage, the projection mapping technique has rarely been used to enhance the overall object of the projection. The events in which the architecture was dismantled, elaborated, distorted through the projection of videos and those

in which the facades were used as large urban screens, the mapping rarely offered new contents concerning the cultural heritage on the architecture that hosted the show [1-2].

The SOGNO O SON DESTE project, conceived by the Vignola Foundation and today also supported by other local banking foundations, started in 2017 [3], gathering the patronage of the municipal administrations involved: MIBACT, the Polo Museale dell'Emilia-Romagna and the University. Through the use of projection mapping, we aimed to reconstruct the wall decorations of some Estense dwellings based on the few remaining fragments. On some external portions of the Rocca di Vignola and on the walls of the cloister of Casa Romei it was possible to hypothesise the development of the decorations and, through mapping, reproduce them in their entirety (July and October 2018, figure 1). The process identified to carry out the mapping involved numerous actors with different skills and, throughout its course, took on characteristics that diverge from classic projection mapping. In particular, the use of static images (instead of dynamic images), the periodicity of the event, the goal of integrating with existing architecture and decorations, approximated the enhancement project to a light design rather than real mapping.

As described in other studies of the same research group [4], the mapping presents intrinsically limiting characteristics to achieve the goal of integrating the decorations: the synthesis of additive type colors typical of light sources (different from the subtractive one of painting) and the discontinuities of the surface (walls with brick portions and plastered portions) significantly affect the color rendering of the reconstructions. Furthermore, the static nature of the projected images also highlights possible small misalignments between the projection and the support, which would be usually masked by the typical animations of projection mapping.

2. The project and the new workflow

The new intervention outlined in this research, started in 2019, was designed on the experiences gained in the past year. This time, the objects of the projection (albeit of more modest size) asking new questions forced the group to define an adequate workflow.

- The entrance area of the Rocca di Vignola was entirely mapped: two of the areas involved projection on flat surfaces, while the third concerns the barrel vault that covers the entrance hall, on which the coffered motif is now only partially visible.

- On the other hand, inside Casa Romei (Ferrara) we chose to recreate a fresco of the crucifixion of Christ, detached from the church of Santa Caterina, in former via Roversella, dating back to the mid-fourteenth century and made by an unknown Ferrarese author. This artwork presents a critical gap, the result of a detachment made in 1846, preserved today in the Ricasoli-Firidolfi palace in Florence [5].

As mentioned, for different reasons, both the first and the second subjects forced a review of the overall workflow. It was necessary both getting a geometric control of artefacts (not merely depicted on a flat surface), and developing a process to manage the color profile of the pictures of existing frescoes. For these reasons, a workflow has been here outlined, finding a precise role for the different skills, tools and in an integrated process organized in a sequence of connected phases. For each phase identified (Fig. 2), this research group has played a specific role. In particular:

0. Feasibility study and workflow development: selection of technologies and procedures to be implemented for the two subjects;

1. Data acquisition phase: integrated survey of the object with laser scanner and / or digital photogrammetry;
2. Data processing phase: two-dimensional drawings and three-dimensional reconstruction of the main geometries;
3. Setup phase: assistance in the assembly of the projectors and in the management of the projected color;
4. Output phase: validation of results and analysis of any critical issues.

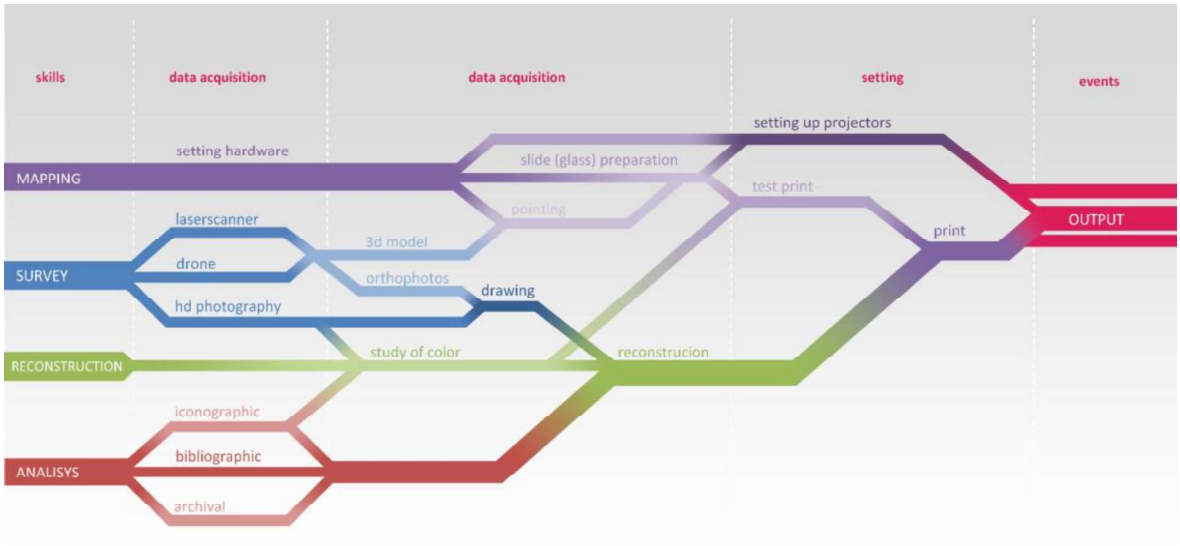


Figure 2. Diagram of the activities and phases in which the Department of Architecture of the University of Ferrara is involved.

3. Managing the geometry: the barrel vault of Vignola

The Rocca di Vignola, whose oldest nucleus according to tradition dates back to the eighth century, still has many decorative testimonies from the fourteenth and fifteenth centuries, among these finds there are the paintings of the entrance vault.

The surveys and preliminary studies conducted by the research group (phase 1) made it possible to give a first interpretation of the surfaces involved, in particular, of the more complex barrel vault covering the entrance hall to the internal courtyard of the Rocca di Vignola. From the data taken through the laser scanner and digital photogrammetry, it emerged that this vault cannot be assimilated to a cylinder, due to its trapezoid-shaped plant. Due to a series of differences typical of a 'real' architectural surface, it is also wrong to approximate it to a "conical" surface (Figs. 3-4). Through other geometric analyses, it was also possible to highlight that the range of the sections is not uniform. From figure 3 it is observed that the variation in the total radius of 81 cm between the first and last section does not correspond to a similar variation in the key of the vault, which instead only has 7 cm.

The three-dimensional surveys with laser scanner were followed by a photographic campaign aimed at creating the 3D model for photomodeling. This saw the use of a reference color scale, the same that will be shared by all the actors in the various phases from relief to printing.

The photographic images of the areas involved in the project, processed with the Metashape (Agisoft) software, allowed the production of textured models. From the overlap between the data generated by photomodeling and that obtained with the laser scanner, it is possible to check measurements, morphologies, and refine or correct the model itself. A first

postproduction of the models led to the extraction of the textures of the surfaces in raster format and the creation of the meshes of the portions of masonry affected by the projection (Figs. 5-8).

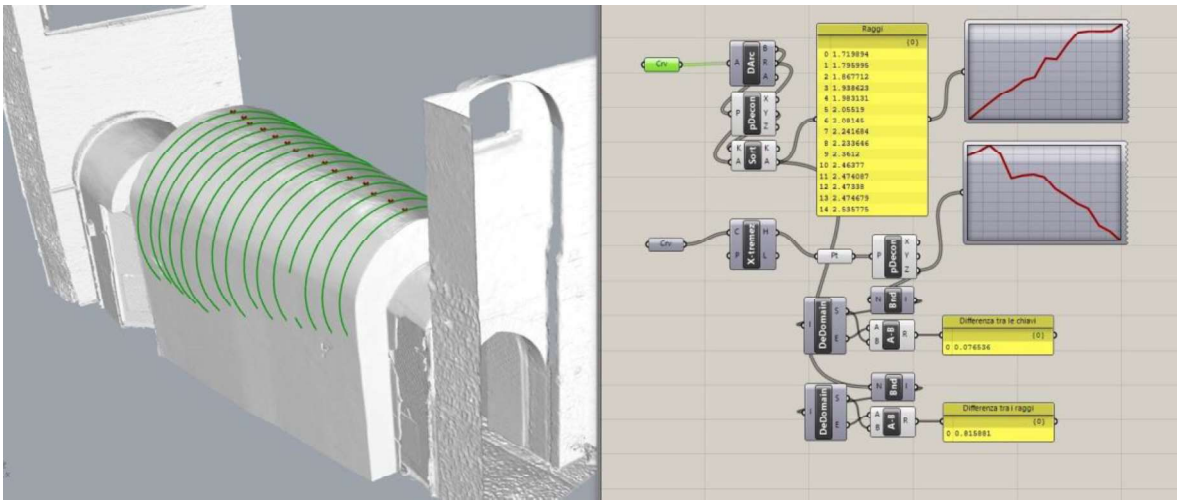


Figure 3. Analysis of the sections: the two graphs in the top right indicate the variation in radius of the sections of the vault (carried out every 50 cm) and the key of the vault.

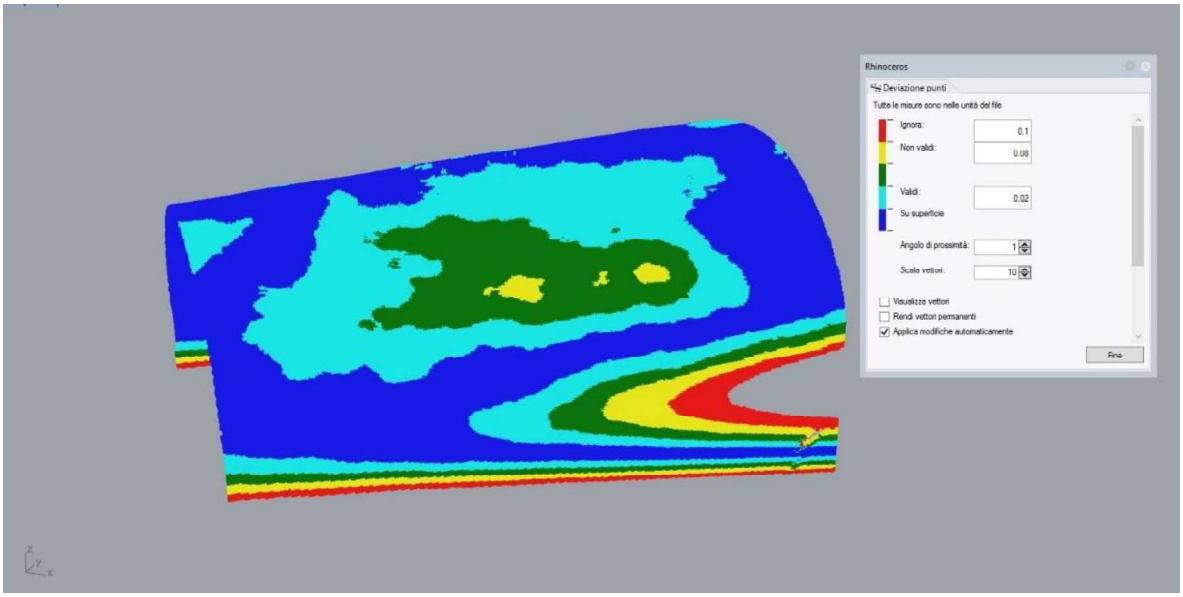


Figure 4. Map of the deviation between a perfect conical Surface and the real Surface. Notice how in some áreas (in red) the discrepancy is over 10 cm.

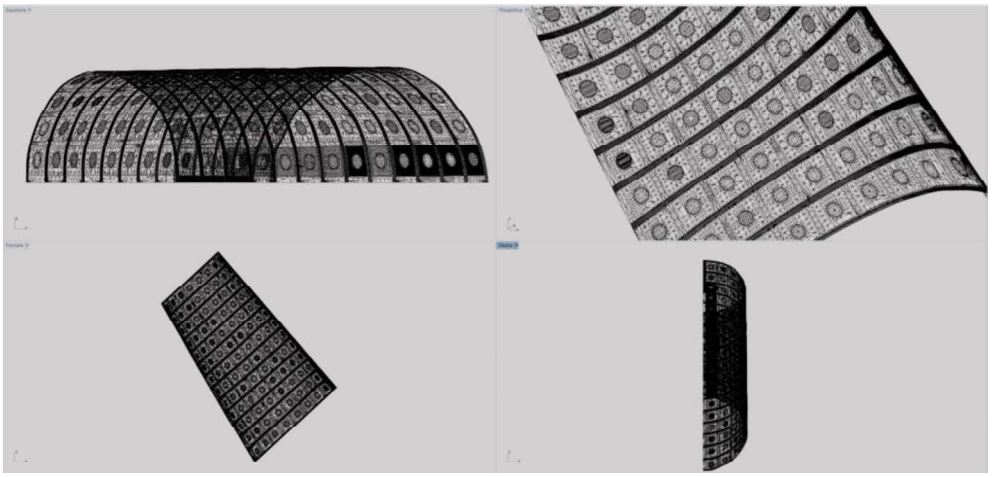


Figure 5. The geometry of the lacunars is directly traced onto the three-dimensional model, starting from the fragments of the decorations.

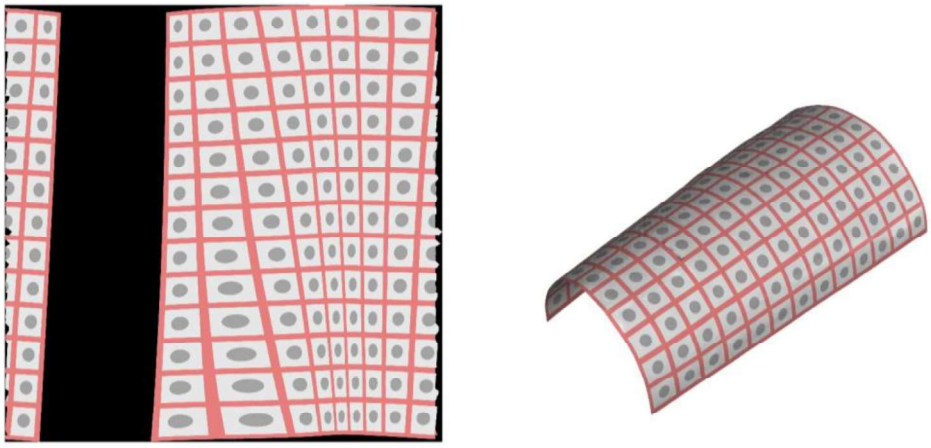


Figure 6. The extraction of the texture was then carried out employing a cylindrical projection. Reconstruction of the lacunars of the barrel vault made on the basis of the texture obtained through the cylindrical projection (UV mapping).

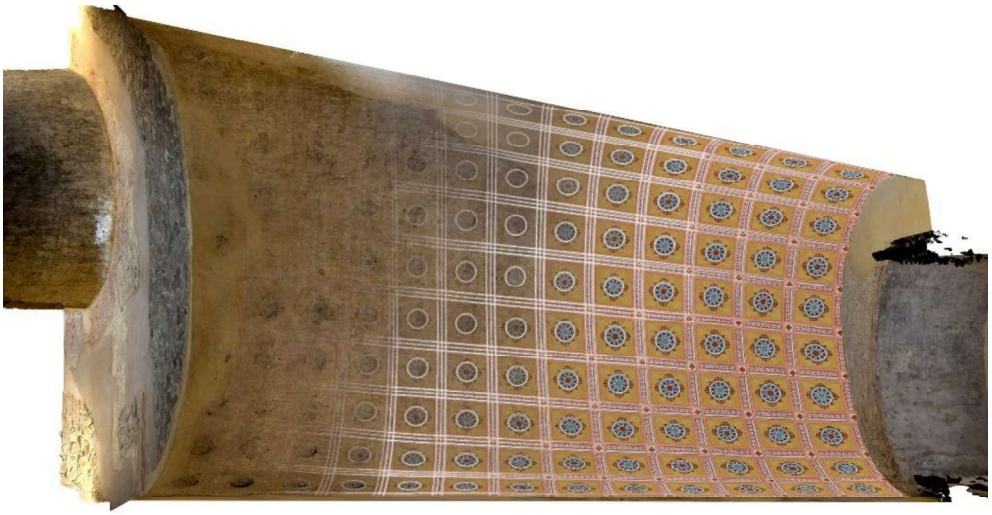


Figure 7. Image of the elaboration of the barrel vault of the Rocca di Vignola. From left to right: textured model obtained from the photomodeling process; three-dimensional vector redesign of the grid of the lacunars; texture of the decorations reconstructed and digitally reworked by the restorer.

Subsequently, within the Rhinoceros software, it was possible to create the vector graphics necessary for the reconstruction of the disappeared decorations. In particular, we proceeded

to trace the geometry of the lacunars directly onto the three-dimensional model, starting from the fragments of the decorations (Fig. 5). It became necessary to work directly on the three-dimensional model, since the surface, as mentioned, had irregularities that did not make it developable. Following this process, it was possible to create a first texture that carried out the basic geometries of the lacunars.

The extraction of the texture was then carried out employing a cylindrical projection (Fig. 6). In this way, it was possible to create a stable one-to-one correspondence (UV mapping) between the three-dimensional model and the two-dimensional texture, keeping the deformations sufficiently homogeneous within the raster image. This procedure was useful because the texture thus produced constitutes the necessary basis for the reconstruction of the decorations, allowing us to maintain a homogenous degree of detail within the image. The digital image processed by the restorers was therefore reused as the texture of the previous model (Fig. 7).

The renderings were then extracted from this, at a resolution appropriate to the technical characteristics of the slides, placing the camera in the projection center of the fixed projectors. To do this, the seven projectors were first fixed in the physical environment of the Rocca. Subsequently, after a new survey by photomodeling, their position was calculated to pass to the rendering phase (Figs. 8-9).

The seven images thus obtained were subjected to a subsequent warping phase (as foreseen by the classic projection mapping workflow), to cut out the projection areas and correct the last deformations that could be caused by the lenses of the projector itself.

Figure 8. The seven projectors were first fixed in the physical environment of the Rocca and then their necessary position was calculated to set the rendering phase.

Figure 9. The sequence of geometric operations carried out to determine the definitive projection. Left to right: 3d digital model with cameras placed in the projection points; 3d model mapped with reconstructed texture of lacunars; picture of the final projection on the real vault

4. Managing colour: Vignola and Casa Romei

To reconstruct the frescoes of Vignola we started from the base of the existing fragments of the decorations. In this case, the reconstruction (including the choice of colors in the redesign phase) is entirely entrusted to the restorer. Through the observation of the fragments, the analysis of the pigments and the study of the historical context, the restorer selects and recreates the most probable colors. The case of Casa Romei was different.

In the main hall of the museum it is kept a Crucifixion of Christ by an unknown artist dated 1350. The scene, the fulcrum of a complex program, was detached from a wall of Santa Caterina di Ferrara church in 1935. At the bottom, on the left side, a gap interrupts the account of which you can imagine, however, the sense thanks to parts of garments attributable to human figures. Through this project, thanks to graphical re-composition of the whole cycle and a projection of light on the fresco cited above, he wants to compensate the gap and return an iconographic and perceptual reading whole story (Fig. 10). The fresco was shot completely photographically and then later re-projected into the corresponding gap of the original fresco for integration. Since the two portions are kept in distant places, the only procedure identified that allowed a comparison of the color was that of using a double photographic shot with a controlled color profile. To do this, a high-resolution photographic acquisition of the fragment preserved in Florence was carried out. The color was then corrected by applying the color profile obtained with the aid of the *Color Checker*. The same operation was then carried out on the main fresco in Ferrara (Fig. 11). In this way it was possible to directly compare the two frescoes and appreciate the chromatic discrepancies.

The high resolution image of Casa Romei fresco is made by Ghigo Roli. The one of Florence fragment is the work of the Department of Architecture of Ferrara (Fig. 12). Both images were acquired in high resolution (gigapixel), stitching a series of photos made by rotating the machine around the nodal point. In addition, the color checker was used for both images, to create in post-production phase, a color profile allowing a comparison between the images. From the analysis, it has been observed that following the different restorations that involved the two portions of the fresco at different times and ways, these now show different chromatic characteristics. In particular, the Florentine fragment underwent a restoration in which the micro-gaps were all integrated in order to recreate the pictorial continuity of the subject. Instead, in the portion of Ferrara the colors are weaker, and no gap has ever been integrated. In addition, the latter lacks the golden colors of the aureoles, which are present

in the splendid Florentine fragment. Given the purpose of the project is that of integration, it was decided to proceed with a correction of the projected fresco in order to make it comparable with the existing one.

To control the color, a verification of the projection process is necessary. As mentioned above and as described in previous studies, the choice of gobo projectors during the design phase, i.e. analogical image projectors printed on a filter. With such projectors, the projection color management must occur at the print level. This takes place through a marking process called "laser ablation": in short, the glass filter has a coating layer on one side on which the laser acts gradually, removing layers according to the desired color.

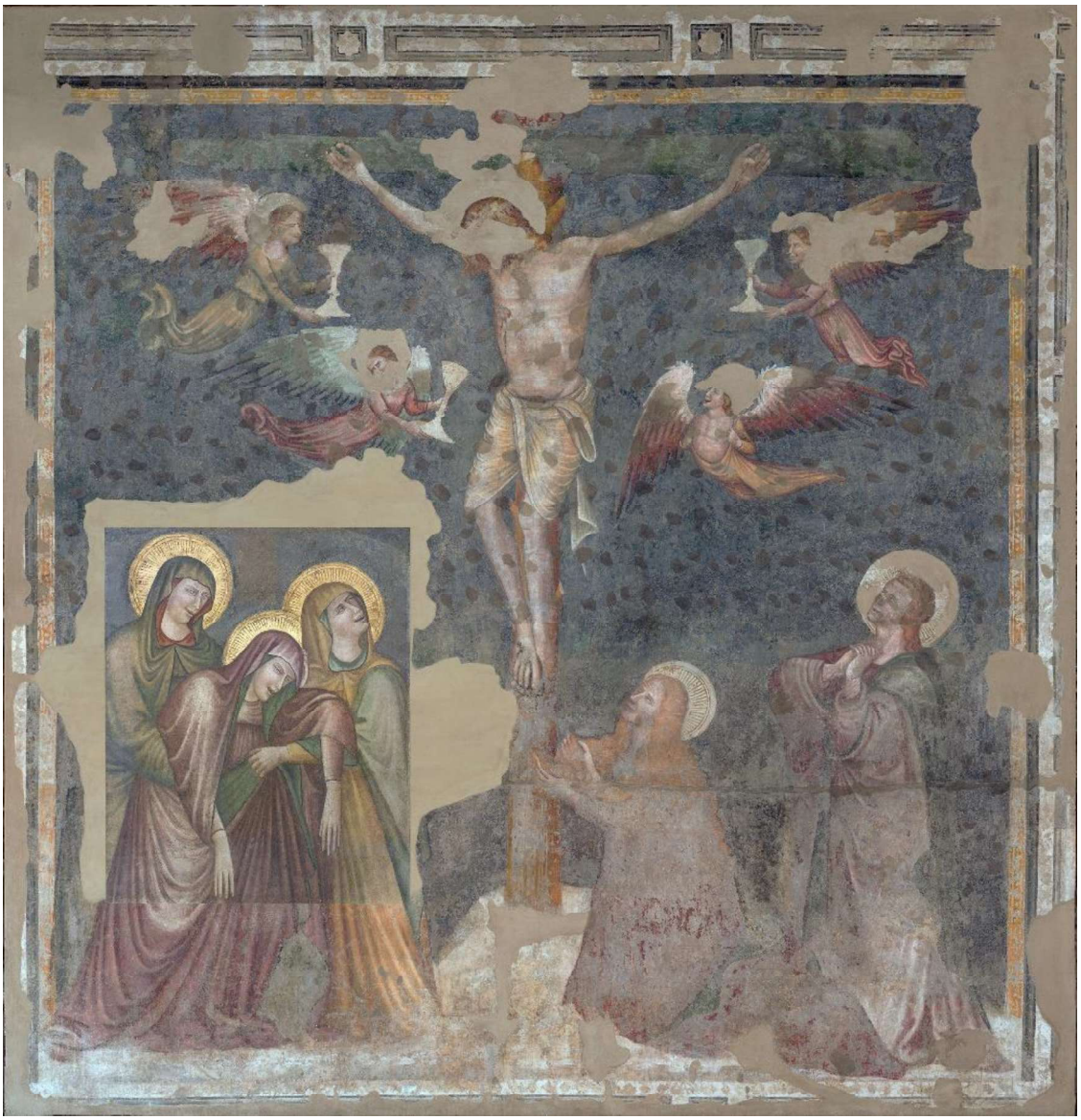


Figure 10. Fresco of the crucifixion of Casa Romei with the insertion of the fragment preserved in Florence.

Since laser ablation is not yet subject to rigorous numerical control, but is entrusted to the operator's experience, the verification of the actual color rendering takes place only afterwards through various tests, where color samples are projected onto the surface which then will host the final screening. In these circumstances, other photographic shots were taken for comparison with the original digital file. Finally, the last phase involves assistance with the final setup with the control of the balance between projected lights and ambient lighting.

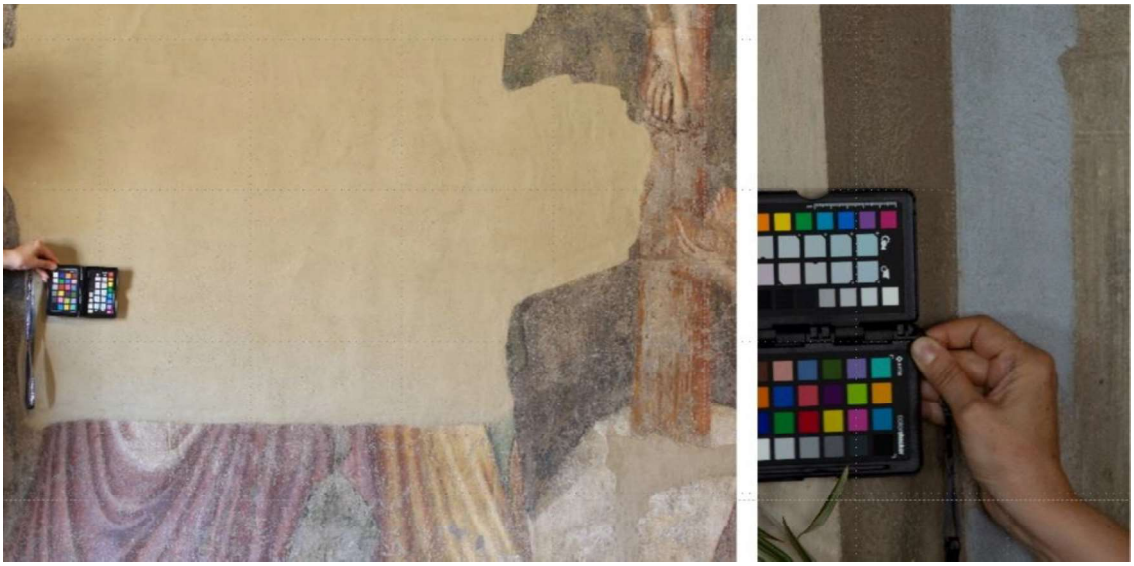


Figure 11. Photograph of the fresco of the crucifixion at the height of the gap, with the colorchecker superimposed.

Figure 12. Left: full image of the three women; right: detail in 1:1 scale from the high-resolution image of the same subject. We are grateful to Giovanni Ricasoli Firidolfi for granting us permission.

The results of this technique were not judged satisfactory enough: the possibility of approaching the Crucifixion would in fact have allowed the visitor to read the structure of

the pixels of the slide, causing the loss of visual continuity between the existing artifact and the projected image. For this reason, for the first time, it was decided to use a traditional type of digital video projector, hung from the ceiling (Figs. 13-14).

Figure 13. Left: the original test slide image: the image of the "three women" was divided into four different sections, on which four different colour balance settings and four different ways of dealing with the edge of the projection were tested. Right: projection test carried out with a traditional projector. On this occasion, the rendering of colors on the material support (of warm tones) and the connection between the existing fresco and the detached one were evaluated

Figure 14. Fresco of the crucifixion of Casa Romei with the projection mapping inaugurated in 2021 and the totem containing the descriptive video. In the final phase, for better chromatic coherence and fidelity of detail, it was decided to project the image with a digital video projector.

Conclusion

The workflow described in this way pursues the aim of maintaining geometric and colorimetric coherence in all the processing phases, guaranteeing, as per set objectives, the best possible integration between the reconstructed decoration and the existing one and ensuring the overall enhancement of the architectural asset.

As described, the object of this research is configured as a light-design project in which the light is declined according to alternative layouts, with the specific purpose of enhancing the space, recreating specific atmospheres and enriching their use by offering new interpretations.

At the time of writing, the projections in the entrance to the Rocca di Vignola were inaugurated to the public (7 December 2019), while the conclusion of the Crucifixion project of the Museo di Casa Romei was postponed to 2021 due to the Covid pandemic [6]. The fruition of this last cultural heritage was enhanced with the creation of a 5.30 minute video (Fig. 15), explaining the history of the crucifixion, from the foundation of the church that hosted up to the hypothesis of the recomposition of the entire wall on which it was positioned the fresco.

It is therefore assumed that it will soon be possible to evaluate the final result of both experiences and analyze any critical issues.

Figure 15. Frame from the explanatory video created by the authors for the project to promote the Crucifixion, displayed on media stations at Casa Romei.

Acknowledgments

Supervisor project SOGNO O SON DESTE: Achille Lodovisi; Director Museum Casa Romei: Andrea Sardo; Architectural surveys and results: Stefano Giannetti, Manuela Incerti; Reconstruction of geometries and decorations of the Rocca di Vignola: Stefano Giannetti; Artistic and pictorial reconstruction of the Rocca di Vignola: Natalia Gurgone, Laura Vignoli; Projection mapping: Marco Grassivaro, Federico Bigi by Apparati Effimeri; High resolution photographs of the frescoes of Vignola and of the fresco of the crucifixion of Casa Romei: Ghigo Roli; High resolution photographs of the fresco of Florence: Stefano Giannetti, Manuela Incerti. Geometric and colorimetric management of images: Stefano Giannetti. Paragraphs 1, 2 and 5 were written by Manuela Incerti, 3, 4 and 5 by Stefano Giannetti. Scientific coordination for the Department of Architecture: Manuela Incerti.

We kindly thank Giovanni Ricasoli Firidolfi and Uliva Velo for the operational support for the data collected in Florence. We also thank Vignola Foundation, BPER Banca (sole

sponsor for Casa Romei), Estense Foundation and Modena Foundation for supporting our research.

The research was also carried out with the support of the instrumentation financed with the University UNIFE FIR 2017.

References

[1] Lo Turco M. Teatri urbani e affreschi di luce. Raccontare il territorio con le tecnologie digitali. Luigini A, Panciroli C, editors. Ambienti digitali per l'educazione all'arte e al patrimonio. Milano: Franco Angeli; 2018, p. 151–171.

[2] Maniello D. Augmented Heritage per la per la valorizzazione dei beni culturali. Suoni e luci per il Königorgel di Nijmegen. DISEGNARECON 2016; 9(17): 8.1-8.10.

[3] Lodovisi A. Tracce in luce. Atti e Memorie della Deputazione di Storia Patria per le Antiche Provincie Modenesi 2018; XI (XL): 59–92.

[4] Giannetti S, Lodovisi A, Sardo A, Grassivaro M, Incerti M. Esperienze di projection mapping per la valorizzazione delle facciate dipinte nei territori estensi. Experiences in projection mapping. Enhancing the painted facades of the Estes. In P. Belardi, editor. UID 2019 - Riflessioni: l'arte del disegno/il disegno dell'arte / Reflections: the art of drawing/the drawing of art. Roma: Gangemi; 2019, p. 1621–1628.

[5] Lamborghini G. Il tassello mancante nella Crocifissione di Santa Caterina Martire. Voci di una città 2018; 28: 15–17.

[6] Incerti M, Giannetti S, Lodovisi A, Sardo A. Dal rilievo al projection mapping. La ricomposizione degli affreschi della chiesa di Santa Caterina Martire in Ferrara / From the Survey to Projection Mapping. The Recomposition of the Frescoes of the Church of Santa Caterina Martire in Ferrara. Connettere. Un disegno per annodare e tessere. Atti del 42° Convegno Internazionale dei Docenti delle Discipline della Rappresentazione/Connecting. Drawing for weaving relationships. Proceedings of the 42th International Conference of Representation Discipline. Milano: Franco Angeli, 2020, p. 3365–3382.